

Modeling the Microstructural Evolution of Metallic Polycrystalline Materials under Localization Conditions

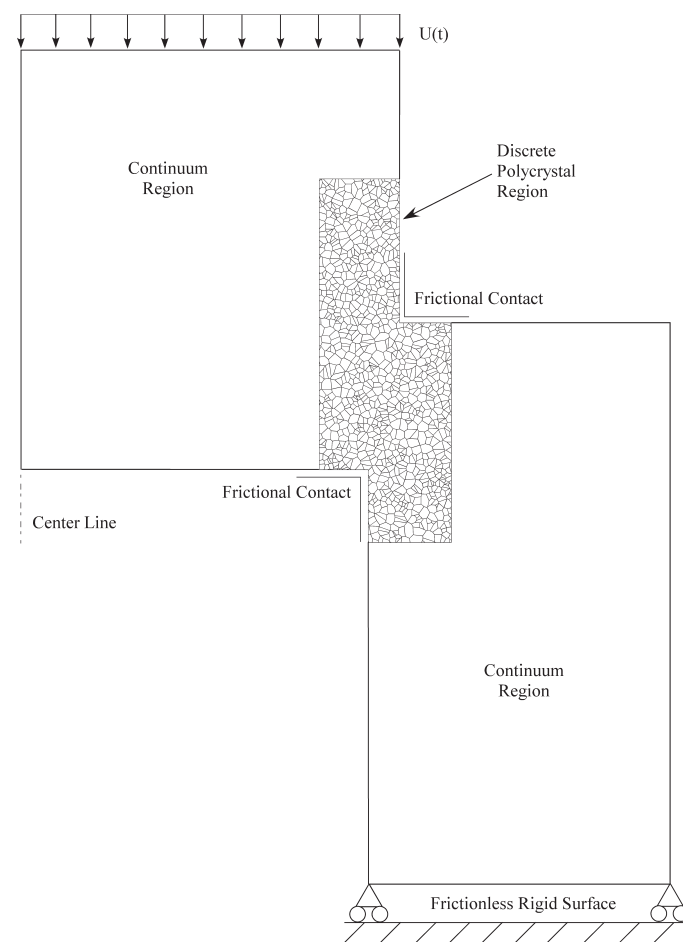
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In general, the shear localization process involves initiation and growth. Initiation is expected to be a stochastic process in material space where anisotropy in the elastic-plastic behavior of single crystals and intercrystalline interactions serve to form natural perturbations to the material's local stability. A hat-shaped sample geometry was used to study shear localization growth. It is an axisymmetric sample with an upper "hat" portion and a lower "brim" portion with the shear zone located between the hat and brim. The shear zone length was 870,890 μm with deformation imposed through a Split-Hopkinson Pressure Bar system at maximum top-to-bottom velocity in the range of 8–25 m/s. The deformation behavior of tantalum tophat samples is modeled through direct polycrystal simulations. An embedded Voronoi-tessellated 2D microstructure is used to represent the material within the shear zone of the sample. A thermomechanically coupled elastoviscoplastic single-crystal model is presented and used to represent the response of the grains within the aggregate shear zone. In the shoulder regions away from the shear zone where strain levels remain on the order of 0.05, the material is represented by an isotropic J2 flow theory based upon the elastoviscoplastic mechanical threshold stress (MTS) model for flow strength. The top surface stress-versus-displacement results were compared with those of the experiments, and overall the simulated stress magnitude is overpredicted. It is believed that the reason for this is that the simulations are 2D. A region within the numerical shear zone was isolated for statistical examination. The vonMises stress state within this isolated shear zone region suggests an approximate normal distribution with a factor of two difference between

Fig. 1. Two-length scale numerical model used to simulate the tophat sample. This figure is drawn to scale.

the minimum and maximum points in the distribution. The equivalent plastic strain distribution within this same region has values ranging between 0.4–1.5 and is not symmetric. Other material state distributions are also given. The crystallographic texture within this isolated shear zone is also compared with the experimental texture and found to match reasonably well considering the simulations are 2D.

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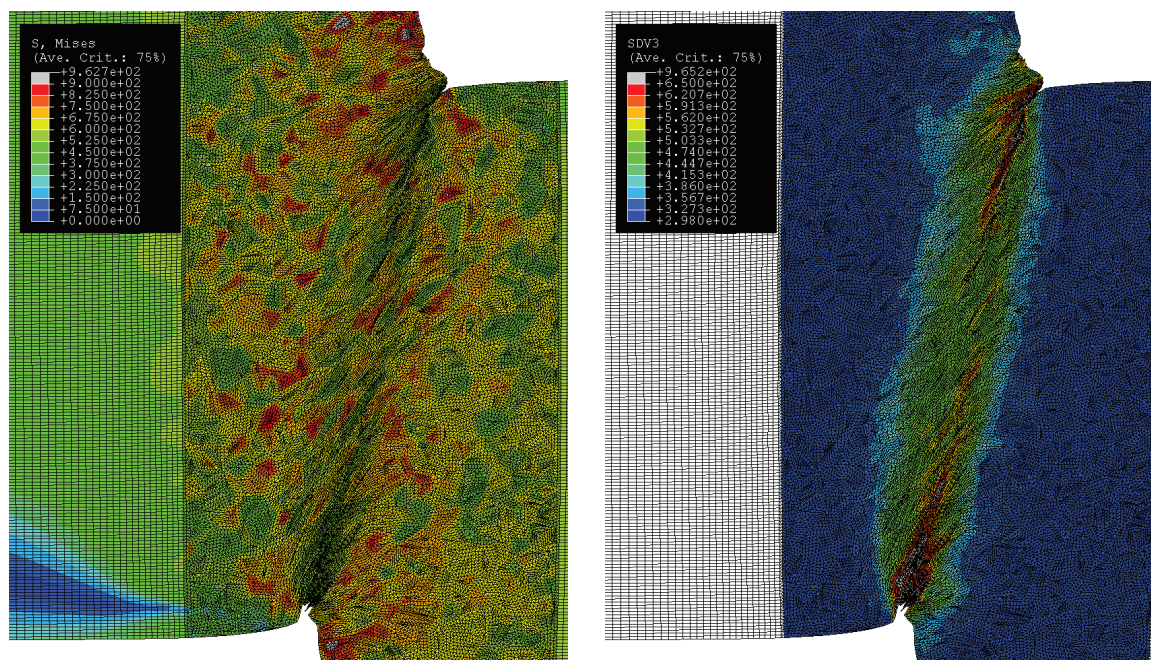


Fig. 2. vonMises stress (left, MPa) and temperature (right, K) results from the Tantalum top hat experiment numerical simulation.

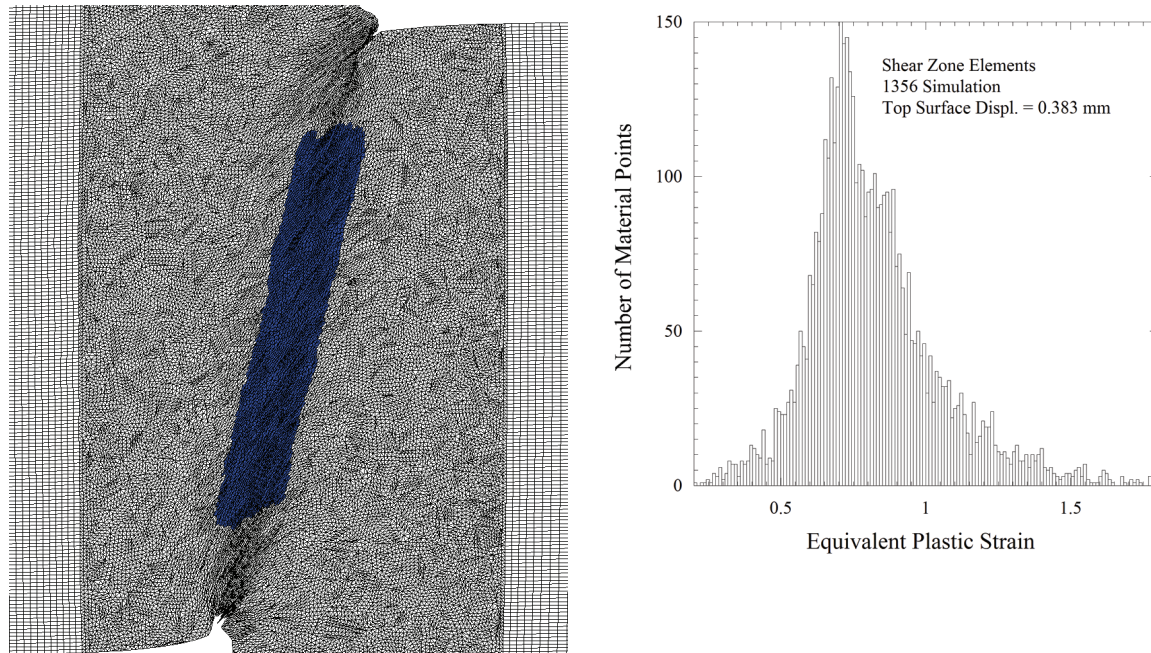


Fig. 3. Distribution of equivalent plastic strain in the highlighted region of the shear zone.

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